An update on newer pediatric supraglottic airways with recommendations for clinical use

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Introduction
Supraglottic airways (SGAs) may be pragmatically defined as a device that facilitates oxygenation and ventilation while sitting immediately outside the larynx to form a perilyngeal seal. SGAs are an established part of routine and emergency pediatric airway management, including use in the difficult airway and neonatal resuscitation.

Supraglottic airways may be classified as first- or second-generation devices based on the presence of a gastric access channel (1). First-generation devices are simple airway tubes attached to a mask that rests over the glottic opening. Second-generation devices incorporate a gastric access channel that allows for gastric venting, and the option to place a gastric tube. Correct placement of an SGA results in the leading edge of the device to rest in the upper esophagus, creating a ‘second seal’ or hypopharyngeal seal. Second-generation devices typically provide a better ‘second seal’ which can support higher airway pressures than first-generation devices. The improved airway seal with the added gastric access channel helps reduce the risk of gastric insufflation, allows for more effective positive pressure ventilation (PPV), and offers some protection against unexpected regurgitation and aspiration (2,3).

Since the introduction of the first SGA 30 years ago, many variations of new first- and second-generation devices have been designed to improve ease of insertion, PPV, and facilitate tracheal intubation. This review aims to briefly present the evidence surrounding the use of established pediatric first- and second-generation SGAs: the laryngeal mask airway Classic, laryngeal mask airway ProSeal, which were introduced into clinical practice in 1987, 1997, and 2000, respectively; and to provide a more detailed critique of newer pediatric SGAs: the air-Q, laryngeal mask airway Supreme, i-gel, and Ambu Aura-i, which have the most evidence to support their use in the pediatric population. In addition, this review of the current literature will also provide a summary of recommendations for the use of these newer SGAs in clinical practice. Safety data are difficult to acquire and require extensive use of these devices in thousands of patients, which may bias clinicians against newer devices. As a result,
establishing safety data on newer SGAs can only be obtained over time as the use of these devices becomes more commonplace.

Established SGAs (laryngeal mask airway Classic, laryngeal mask airway ProSeal, laryngeal mask airway Unique): a brief overview

The laryngeal mask airway Classic is a first-generation device without a gastric access channel and is widely used in pediatric anesthesia. The laryngeal mask airway Classic has been shown to be superior to mask ventilation, even when used by inexperienced clinicians (4–7). The hemodynamic stress response associated with laryngeal mask airway insertion is less than that with laryngoscopy and tracheal intubation, and comparable to the insertion of an oral airway (7–10). In routine airway management by inexperienced personnel, the laryngeal mask airway Classic can be faster and easier to insert than a tracheal tube (TT) (4). However, increased technical difficulties and airway complications are noted with decreasing patient age (11,12). Complications include mask displacement, poor airway seal, gastric insufflation, and reflex activation of the airway (13). Despite these areas of concern, the laryngeal mask airway Classic has been safely utilized in pediatric practice.

The laryngeal mask airway Classic is constructed of silicone and designed to be reused up to 40 times. Despite proper sterilization, the risk of infection can remain because autoclaving fails to completely remove prions and protein deposits (14). An evaluation of 50 previously used and sterilized laryngeal mask airway Classics revealed residual protein after one use and increased protein load with each subsequent use (15).

The laryngeal mask airway Unique is a disposable version of the laryngeal mask airway Classic, made of polyvinylchloride (PVC) or silicone (in some countries), and was introduced in 1997. The laryngeal mask airway Unique performs similar to or better than the laryngeal mask airway Classic (16,17). The ease of insertion, combined with a disposable design, may potentially make the laryngeal mask airway Unique a good device for novice users and in out-of-hospital settings.

The laryngeal mask airway ProSeal is a reusable second-generation device that was introduced in 2000. Pediatric-sized laryngeal mask airway ProSeals (1.0–2.5) became available in 2004. In addition to the gastric channel, there is a built-in bite block to prevent airway obstruction. A deep mask bowl improves the hypopharyngeal seal, which facilitates PPV. Compared with the laryngeal mask airway Classic, the laryngeal mask airway ProSeal has the same (18) or better (19) airway leak pressures with decreased rates of gastric insufflation (2,18–24). Higher first-attempt insertion rates and higher leak pressures were also seen in neonatal resuscitation studies utilizing manikins with the laryngeal mask airway ProSeal when compared with the laryngeal mask airway Classic (25,26). The laryngeal mask airway ProSeal has been shown in a variety of clinical trials to outperform the laryngeal mask airway Classic, and can be an effective means for mechanical ventilation (2,18,20,22,23,27,28).

Key concepts

The airway seal of various first-generation SGAs and their leak volumes are largely dependent on the inflation status of the cuff, which has been shown to be less than the usual recommended range (<60 cmH2O), for optimal performance (29–31). Lower cuff pressures have also been shown to be beneficial with the laryngeal mask airway Supreme (32). However, there is insufficient evidence to definitively recommend the best cuff pressure for optimal clinical performance with second-generation SGAs. Based on these studies, it is conceivable that a lower cuff pressure for newer SGA devices may be better airway sealing characteristics. In addition, the anatomic positioning of smaller sized SGAs does not necessarily correlate with the functionality of the SGA, and ventilation can be effective, despite significant downfolding of the epiglottis on fiberoptic examination (33,34). This is also true with the newer SGAs (35–38).

Both the laryngeal mask airway Classic and the laryngeal mask airway ProSeal have a strong evidence base supporting their use in children. Therefore, newer SGAs should be compared with these established standards when evaluating their efficacy (1).

Newer SGAs

First-generation devices

air-Q

The air-Q is an oval-shaped laryngeal mask with a shortened, wide, curved airway tube. The air-Q mask contains an elevated keyhole-shaped ventilating orifice designed to prevent epiglottic downfolding (Figure 1); however, epiglottic downfolding can still occur in smaller children (37,39).

The air-Q has three versions, and is manufactured as a reusable or single-use device:
1. Standard cuffed
2. Self-pressurized (air-Q SP; lack of an inflatable cuff)
3. air-Q with an esophageal blocker; a second-generation device which allows for evacuation of gastric contents; not yet available for children.
The air-Q SP performed well in a large observational study of several infants and small children (40). A randomized trial of children weighing 10–15 kg found higher airway leak pressures when the cuffed air-Q was used for routine anesthetic maintenance, as compared with the laryngeal mask airway Unique (35). The air-Q was also reported to have superior fiberoptic views of the larynx. Another randomized trial compared the air-Q SP with the laryngeal mask airway Unique in older children. The two devices performed similarly in terms of airway leak pressure, fiberoptic views, and complication rates (36). The cuffed air-Q was shown to be associated with higher airway leak pressures and superior fiberoptic views when compared with the flexible laryngeal mask airway in infants weighing less than 10 kg (41). Various studies have reported that leak pressures with the air-Q are similar (36) or higher (35) than the laryngeal mask airway Unique, but lower than the laryngeal mask airway ProSeal (42).

In addition to its use in routine anesthetic maintenance, the air-Q was also designed to assist tracheal intubation in both infants and children (37,39,43). Several reports suggest that the air-Q does offer advantages over traditional laryngeal masks and the Ambu Aura-i when used as a conduit for fiberoptic-guided tracheal intubation in children (39,41,44). Compared with the Ambu Aura-i, both devices performed well as conduits for tracheal intubation including similar success rates, time to tracheal intubation, and fiberoptic views (39). However, the utility of the Ambu Aura-i size 1.5 with cuffed TT was limited by its narrower airway tube, which could not accommodate the passage of the TT pilot balloons. The air-Q design has a shorter, wider airway tube to facilitate passage of cuffed TTs and subsequent removal of the air-Q after tracheal intubation (37,39). The largest TT that can be accommodated by the air-Q is printed on the dorsal aspect of the airway tube. The removal process has been shown to be effective with low risk for inadvertent tracheal extubation when a removal stylet is used to stabilize the TT during air-Q removal (37,39,43,44).

The air-Q may be a useful tool in small children, as it was shown to require fewer maneuvers to optimize the fiberoptic glottic view for tracheal intubation when compared with a traditional free-handed fiberoptic intubation in children with normal airways (45). The air-Q has also been used successfully in children with anticipated and unanticipated difficult airways (46–53), while allowing for the use of cuffed TTs. A retrospective evaluation of anticipated and unanticipated difficult airways found that the air-Q was used successfully as a conduit for intubation in all cases (47). A case series showed that in children with craniofacial abnormalities (limited mouth opening), the air-Q provided adequate ventilation even when downsized, and was still an effective conduit for fiberoptic-guided tracheal intubation with an appropriately sized cuffed TT (44). This ability to facilitate tracheal intubation with larger cuffed TT even with a smaller air-Q may be an advantage over the laryngeal mask airway Classic. The air-Q has also been used to successfully relieve upper airway obstruction during rapid sequence fiberoptic intubations (53) as well as facilitate oxygenation while performing fiberoptic tracheal intubations in children with predicted difficult airways (44,47,49,53).

In addition, the air-Q may prove to be beneficial in neonatal resuscitation. In a neonatal manikin resuscitation study, novices found the air-Q easier to use than the Soft Seal laryngeal mask for emergency airway management during chest compression (54). Table 1 summarizes the studies performed with the air-Q in children.

Second-generation devices

The most established second-generation device is the laryngeal mask airway ProSeal, and it is associated with a long history of safety and efficacy for various procedures in children (1,55). Newer second-generation devices include the laryngeal mask airway Supreme and the i-gel. A recent survey of 240 anesthetists in the United Kingdom showed that adoption of second-generation devices for use in children has been slow, with 88% preferentially using first-generation devices (56) and citing safety concerns as the determining factor. The choice of SGA was also largely influenced by departmental preference and personal choice.
Laryngeal mask airway Supreme

The laryngeal mask airway Supreme is a single-use, second-generation device made of PVC. It was designed to combine features of the laryngeal mask airway ProSeal (gastric access and high airway leak pressures) and the laryngeal mask airway Fastrach (curved, rigid airway to facilitate easy insertion). The airway tube of the laryngeal mask airway Supreme also incorporates a bite block at its proximal end, and has a drain tube that travels through the center of the device and exits out of the leading edge of the mask (Figure 1). The ventilating orifices are located on either side of the mask bowl with overlying epiglottic fins to prevent epiglottic trapping. The proximal portion of the laryngeal mask airway Supreme mask is also relatively larger than the laryngeal mask airway ProSeal.

The laryngeal mask airway Supreme has been evaluated in a number of studies performed in children. These are summarized in Table 2. Several randomized trials comparing the laryngeal mask airway Supreme with the laryngeal mask airway Unique have shown that the laryngeal mask airway Supreme provided good gastric access, and had reduced rates of gastric insufflation with similar (32) or higher airway leak pressures (57). Compared to the i-gel, the laryngeal mask airway Supreme was shown to have lower airway leak pressures (58). However, no differences in the overall clinical performance were noted, including the ability to provide PPV. In a study simulating a difficult airway scenario, the laryngeal mask airway Supreme was associated with higher airway leak pressures than the i-gel. The laryngeal mask airway Supreme was also associated with higher first-attempt success rates and faster times for successful insertion (59). A study comparing the laryngeal mask airway Supreme with the laryngeal mask airway ProSeal showed the laryngeal mask airway Supreme to be easier to insert, and associated with less pharyngeal injury (60). In addition, another study comparing the laryngeal

<table>
<thead>
<tr>
<th>Author</th>
<th>Study population; device size(s)</th>
<th>Type of study; device(s)</th>
<th>Primary findings</th>
<th>Secondary findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jagannathan et al. (40)</td>
<td>352 children; 69 infants; all pediatric sizes</td>
<td>Observational: air-Q SP</td>
<td>99% insertion success rate</td>
<td>No difference in complication rates in infants vs older children</td>
</tr>
<tr>
<td>Whyte et al. (42)</td>
<td>110 infants and children; all pediatric sizes</td>
<td>Observational: air-Q cuffed</td>
<td>Ventilation was adequate in 108 of 110 cases</td>
<td>Fiberoptic view of the vocal cords was obtained in 102 of 110 cases</td>
</tr>
<tr>
<td>Komasawa et al. (54)</td>
<td>24 novice doctors on a neonatal manikin</td>
<td>Observational: air-Q Soft Seal laryngeal mask airway</td>
<td>Insertion time during chest compressions was faster with the air-Q than the Soft Seal (P &lt; 0.05)</td>
<td>n/a</td>
</tr>
<tr>
<td>Sinha et al. (43)</td>
<td>20 infants; sizes 1.0, 1.5</td>
<td>Observational: air-Q cuffed for tracheal intubation</td>
<td>Tracheal intubation successful in 19 of 20 patients</td>
<td>Mean time to device insertion was 13 s; mean time to intubation was 96 s</td>
</tr>
<tr>
<td>Jagannathan et al. (35)</td>
<td>50 children; sizes 1.5, 2.0</td>
<td>RCT (crossover design): air-Q vs laryngeal mask airway Unique</td>
<td>Mean leak pressure was higher with the air-Q: 19 vs 16 cmH2O (P = 0.01)</td>
<td>Better fiberoptic views of glottis with air-Q</td>
</tr>
<tr>
<td>Jagannathan et al. (36)</td>
<td>60 children; size 2.0</td>
<td>RCT: air-Q SP vs laryngeal mask airway Unique</td>
<td>No difference in initial leak pressure and leak pressure measured at 10 min</td>
<td>Median time to successful insertion was faster with the air-Q SP: 12 vs 14 s (P = 0.05); no differences in fiberoptic view of glottis and complication rates</td>
</tr>
<tr>
<td>Jagannathan et al. (39)</td>
<td>120 infants and children; sizes 1.5, 2.0</td>
<td>RCT: air-Q vs Ambu Aura-i for tracheal intubation</td>
<td>No differences in time to tracheal intubation or overall intubation success</td>
<td>Mean leak pressure was higher with air-Q in infants; pilot balloon could not pass through the size 1.5 Ambu Aura-i</td>
</tr>
<tr>
<td>Darlong et al. (41)</td>
<td>50 infants weighing less than 10 kg</td>
<td>RCT: air-Q vs Flexible laryngeal mask airway</td>
<td>Mean leak pressure was higher with the air-Q: 21 vs 17 cmH2O (P = 0.02)</td>
<td>Better fiberoptic views of glottis with air-Q (good view in 84% vs 48% (P = 0.0016)</td>
</tr>
</tbody>
</table>

RCT, randomized clinical trial.

Table 1 Summary of studies performed on the pediatric air-Q
mask airway Supreme with the laryngeal mask airway ProSeal did not show any differences in airway leak pressures, or the overall clinical performance of either device (61). Some studies have also demonstrated that the laryngeal mask airway Supreme is faster to insert than the laryngeal mask airway ProSeal (60,62).

The laryngeal mask airway Supreme has also performed well as a resuscitation device in neonates. One study utilizing neonatal manikin models demonstrated faster insertion times and higher airway leak pressures with the laryngeal mask airway Supreme when compared with the laryngeal mask airway Classic and laryngeal mask airway ProSeal (63).

### i-gel

The i-gel is a single-use, second-generation SGA that contains a noninflatable laryngeal mask made of a gel-like thermoplastic elastomer. The semi-rigid cuff does not

### Table 2: Summary of studies performed on the pediatric laryngeal mask airway Supreme

<table>
<thead>
<tr>
<th>Author</th>
<th>Study population; device size(s)</th>
<th>Type of study; device(s)</th>
<th>Primary outcome</th>
<th>Secondary outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trevisanuto et al. (63)</td>
<td>40 clinicians; size 1.0, 2.0, 3.0</td>
<td>Observational: laryngeal mask airway Supreme, laryngeal mask airway ProSeal, laryngeal mask airway Classic</td>
<td>Maximal inflation pressure and quality perceived by the operator are higher with Supreme than with laryngeal mask airway Classic and laryngeal mask airway ProSeal</td>
<td>Time to effective ventilation with the laryngeal mask Supreme is superior to laryngeal mask airway ProSeal</td>
</tr>
<tr>
<td>Jagannathan et al. (88)</td>
<td>100 patients; size 1.0, 2.0, 3.0</td>
<td>Observational: laryngeal mask airway Supreme</td>
<td>First-time insertion success rate was 97%; overall insertion success rate of 100%</td>
<td>Gastric tube placement was possible in 98% of patients; mean leak pressure was 22 cmH2O</td>
</tr>
<tr>
<td>Jagannathan et al. (57)</td>
<td>50 patients; size 2 device</td>
<td>RCT: laryngeal mask airway Supreme, laryngeal mask airway Unique</td>
<td>Median leak pressure was higher with laryngeal mask airway Supreme: 20 vs 15 cmH2O (P = 0.01)</td>
<td>Laryngeal mask airway Unique was faster to insert; less gastric insufflation with laryngeal mask airway Supreme</td>
</tr>
<tr>
<td>Jagannathan et al. (61)</td>
<td>60 patients; size 2.0</td>
<td>RCT: laryngeal mask airway Supreme, laryngeal mask airway ProSeal</td>
<td>No difference in median leak pressure: 19 vs 18 cmH2O</td>
<td>No differences in ease and success of insertion, fiberoptic views, or complication rates</td>
</tr>
<tr>
<td>Jagannathan et al. (58)</td>
<td>168 patients; size 1.5, 2.0, 2.5</td>
<td>RCT: laryngeal mask airway Supreme, i-gel</td>
<td>Mean leak pressure was higher with i-gel: 20 vs 17 cmH2O (P = 0.001)</td>
<td>The i-gel required a greater number of airway manipulations to maintain a patent airway</td>
</tr>
<tr>
<td>Jagannathan et al. (31)</td>
<td>180 patients; size 1.5, 2.0, 2.5</td>
<td>RCT: laryngeal mask airway Supreme, laryngeal mask airway Unique</td>
<td>No differences in leak pressure between devices at an intracuff pressure of 40 cmH2O vs 60 cmH2O</td>
<td>Less rates of gastric insufflation with the laryngeal mask airway Supreme during positive pressure ventilation</td>
</tr>
<tr>
<td>Kus et al. (59)</td>
<td>60 patients with simulated difficult airway; size 2.0</td>
<td>RCT: laryngeal mask airway Supreme, i-gel</td>
<td>Mean leak pressure was higher with laryngeal mask airway Supreme: 21 vs 19 cmH2O (P = 0.019)</td>
<td>Laryngeal mask Supreme was faster to insert with higher success rate in simulated difficult airway scenario</td>
</tr>
<tr>
<td>Aydogmus et al. (60)</td>
<td>80 patients; size 3.0</td>
<td>RCT: laryngeal mask airway Supreme, laryngeal mask airway ProSeal</td>
<td>Blood staining on removal of device was higher with the ProSeal: 10 vs 3 (P = 0.034) and associated with pharyngeal injury</td>
<td>Laryngeal mask airway Supreme was faster to insert</td>
</tr>
<tr>
<td>Hosten et al. (62)</td>
<td>60 patients; size 2.0</td>
<td>RCT: laryngeal mask airway Supreme, laryngeal mask airway ProSeal</td>
<td>No difference in leak pressure between devices</td>
<td>Laryngeal mask airway Supreme was faster to insert with no difference in overall insertion success rates between devices</td>
</tr>
</tbody>
</table>

RCT, randomized clinical trial.
not require or allow for inflation or adjustment of intra-cuff pressures. Instead, the airway seal is designed to improve as the device warms to body temperature. The noninflatable cuff design has the potential advantage of faster insertion time and reduced morbidity related to cuff hyperinflation (64). Easy and rapid insertion of an SGA may be especially important for emergency situations, difficult airways, or out-of-hospital scenarios. Additional features of the i-gel include a built-in bite block, an epiglottic rest to prevent downfolding, and a gastric access channel (size 1 has no gastric channel) (Figure 1).

Among the newer SGAs, the i-gel has the greatest evidence base, and several observational, randomized studies and meta-analyses evaluating the performance of the i-gel in children are summarized in Tables 3 and 4. An observational study on older children (65) found that the i-gel was easy to insert, and had a mean airway leak pressure of 25 cmH2O. Studies show similar (66) or higher (67–69) leak pressures to the laryngeal mask airway ProSeal, and higher leak pressures when compared with the laryngeal mask airway Supreme (59) or laryngeal mask airway Classic (67,68). Two studies demonstrated no difference in the airway leak pressures between the laryngeal mask airway Classic and i-gel, but found that the i-gel was faster (64) and easier (70) to insert in infants, a population historically at higher risk for mask displacement during anesthetic maintenance with the laryngeal mask airway Classic.

Compared with the Ambu AuraOnce, the i-gel was associated with higher airway leak pressures, longer insertion times (71), and a tendency to slide out of the mouth after insertion. Spontaneous dislodgement of the i-gel was noted by several authors (58,71–73), and may be attributed to a relatively wider conical mask compared with other traditionally designed laryngeal masks. Although the design of the i-gel includes an elliptically shaped tube to prevent axial rotation and increase stability, it has been reported to require positional adjustments during the anesthetic course to maintain airway patency (61). These adjustments were more common when the i-gel was used in smaller children. There was an observed outward displacement of the i-gel that often necessitated downward traction and fixation with tape to maintain a good airway seal (71).

Two recent meta-analyses (38,76) included nine RCTs comparing the i-gel with various SGAs in children. The i-gel was found to have higher airway leak pressures and superior fiberoptic views compared with other SGAs in children, including the laryngeal mask airway ProSeal. However, there were no differences between the SGAs in terms of rates of successful insertion, insertion times, or overall complications. Higher airway leak pressures may be clinically advantageous in settings requiring increased ventilating pressures such as prone positioning, obesity, and lung disease. Table 4 summarizes the RCTs performed on the i-gel.

### Table 3 Summary of observational trials with the pediatric i-gel

<table>
<thead>
<tr>
<th>Author</th>
<th>Study population; device size(s)</th>
<th>Primary findings</th>
<th>Secondary findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beringer et al. (72)</td>
<td>120 children; sizes 1.5, 2.0, 2.5</td>
<td>Median insertion time was 14 s. Manual ventilation was possible in all cases.</td>
<td>Fiberoptic inspection through the i-gel revealed a clear view of the vocal cords in 40 of 48 cases (87%)</td>
</tr>
<tr>
<td>Abukawa, et al. (89)</td>
<td>70 children; sizes 1.5, 2.0, 2.5</td>
<td>Overall first-attempt success rate was 94%. Gastric tube insertions were easy in all patients.</td>
<td>Complication rates were higher in size 1.5 group</td>
</tr>
<tr>
<td>Hughes et al. (73)</td>
<td>154 children; sizes 1.2, 2.0, 2.5</td>
<td>First insertion attempt was successful in 93.5% of patients. Gastric tube placement was successful in 90% of cases. Minor complications occurred in 20% of cases.</td>
<td>Considerable vigilance is required when securing the device</td>
</tr>
<tr>
<td>Beylacq et al. (65)</td>
<td>50 children; size 3.0</td>
<td>Overall first-attempt success rate was 100%. The mean seal pressure was 25 cmH2O</td>
<td>There was no gastric insufflation. Gastric tube insertion was achieved in all cases</td>
</tr>
</tbody>
</table>

### Supraglottic airways as conduits for tracheal intubation

Supraglottic airways are ideal conduits for tracheal intubation in children who cannot be intubated by direct laryngoscopy, and are recommended in difficult airway algorithms (76,77). Advantages include the option for continuous oxygenation during intubation, hands-free operation, and relief of upper airway obstruction in children with difficult airways (53,79,80). Evidence for the
successful use of SGAs in difficult airway scenarios is based on reports from case series and observational studies (80).

Two new SGAs specifically designed to facilitate tracheal intubation are the air-Q (discussed earlier) and the Ambu Aura-i. The Ambu Aura-i is a newer model of the Ambu AuraOnce, and is specifically designed for tracheal intubation with fiberoptic guidance in children. The mask bowl of both of these devices resembles the laryngeal mask airway Classic, but without aperture bars (Figure 1). The airway tube has a 90° angle for easy insertion. Compared to the i-gel and air-Q, the Ambu AuraOnce offers similar fiberoptic views of the glottis (39,71), although it should be noted that the Ambu Aura-i size 1.0 and 1.5 does not permit the passage of cuffed tube. A study evaluating the use of SGAs as a conduit for diagnostic and therapeutic bronchoscopy found that PVC-based devices, including the Aura Once, were associated with more resistance during bronchoscope manipulation than silicone-based SGAs (81).

The i-gel offers equal or better fiberoptic views of the glottis compared with the laryngeal mask airway Classic or laryngeal mask airway ProSeal (64,66,82). The favorable fiberoptic views may suggest a role for the i-gel as a conduit for tracheal intubation; however, no formal pediatric study has been performed to date.

The laryngeal mask airway ProSeal and laryngeal mask airway Supreme may be used as conduits for tracheal intubation, but their narrower airway tubes preclude the ability to directly pass an adequately sized TT through these devices. Therefore, the use of an airway exchange catheter, an intubation introducer (Aintree exchange catheter: for size 3 and larger), or a guidewire technique is required. A two-step technique involves first

![Table 4](image_url)
passing an exchange catheter through the SGA with subsequent removal, followed by insertion of the TT over the exchange catheter, with or without a guidewire (83). Another potential advantage of the SGAs (air-Q) with larger diameter airway tubes is the ability to directly pass a cuffed TT through the device, thus avoiding an additional step and the need for an intubation introducer (53).

Recommendations for clinical use
While the older SGAs have the largest evidence base and are already established in pediatric use, the availability of high-quality data on newer SGA devices suggests the potential benefit of a specific device in certain clinical situations. While the choice of the device used should ultimately be based on experienced clinical judgment, the authors have the following recommendations for the clinical use of newer pediatric SGAs.

Spontaneous ventilation
The existing data suggest that the use of the laryngeal mask airway ProSeal, laryngeal mask airway Supreme, air-Q, and i-gel for spontaneous ventilation in small infants is not associated with the same increased risk for complications as seen with the laryngeal mask airway Classic. However, due to limited number of studies in infants, there is insufficient evidence to recommend one SGA over another in spontaneously ventilating patients. In older children, the evidence base is larger, and all newer SGAs have demonstrated successful efficacy. Therefore, in children, the clinician should choose the device with which he/she has adequate experience.

Positive pressure ventilation
Supraglottic airway use in PPV must take into account higher airway pressures and associated risks for gastric insufflation and aspiration. The air-Q and Ambu Aura-i are both first-generation devices with similar or lower leak pressures compared with the laryngeal mask airway ProSeal, and therefore offer no significant advantage in the setting of PPV for routine anesthesia. The i-gel may be a useful alternative to the laryngeal mask airway ProSeal for PPV, as they both have comparable leak pressures and gastric access capabilities. The i-gel has the added advantage over the laryngeal mask airway ProSeal in that it is disposable and therefore has lower risk for infection transmission. The laryngeal mask airway Supreme has been shown to provide effective PPV as well, but more widespread use of this device is needed to make definitive conclusions.

The difficult airway: conduit for tracheal intubation and rescue device for failed intubation
The role of SGAs for rescue ventilation in the pediatric failed intubation scenario is increasingly being recognized. Most of the evidence to date consists of case reports/series using the laryngeal mask airway Classic. Newer devices such as the i-gel and air-Q have also been utilized for this purpose.

The ability of the air-Q and Ambu Aura-i to accommodate cuffed TTs may offer a genuine advantage over the laryngeal mask airway Classic, especially as cuffed TTs are now routinely being utilized in children. The air-Q has been shown to be effective in the difficult airway population for this purpose. The i-gel may be a suitable conduit for tracheal intubation; however, no formal studies have been conducted yet.

Pediatric/neonatal resuscitation
Insufficient evidence exists to recommend the use of a specific SGA in the setting of pediatric cardiac arrest. Further studies are necessary to compare the advantages and limitations of SGAs over conventional methods currently used in pediatric resuscitation.

Supraglottic airways may also be used to provide ventilation in neonates when bag-mask ventilation and intubation have failed. The American Heart Association and the European Resuscitation Council’s incorporation of SGAs into the guidelines for neonatal resuscitation reflects support for this use. In addition, studies have shown that initial resuscitation with an SGA is both feasible and safe (5,25,26,84–87). Some studies appear to show some advantage to using an SGA over tracheal intubation during neonatal resuscitation, including lower rates of failure, and reduced time to secure the airway (5). Even though newer devices have been shown to be useful, there is insufficient evidence to recommend a particular device at this time.

Emergent airway management
Although tracheal intubation is the preferred method for establishing an airway in emergent situations, SGAs may be used when tracheal intubation may be difficult to perform, such as out-of-hospital emergencies or inter-hospital transport. SGAs are relatively easy to insert blindly, and may provide improved ventilation compared to bag-mask ventilation by inexperienced personnel, which could be a useful intermediate step until a definitive airway can be secured. Second-generation devices may have the added benefit by allowing drainage of gastric contents. However, there is not enough evi-
Table 5 Summary of supraglottic airway devices available for children

<table>
<thead>
<tr>
<th>Devices</th>
<th>Approximate cost per single unit (US dollars)*</th>
<th>Pediatric sizes; recommended weight range</th>
<th>First or second generation</th>
<th>Ease of insertion: first-attempt insertion rate; overall insertion success rate</th>
<th>Leak pressures (reported range) (cmH₂O)</th>
<th>Use as a conduit for fiberoptic (FO)-guided tracheal intubation</th>
<th>Areas of potential concern</th>
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</thead>
<tbody>
<tr>
<td>Established SGAs</td>
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<tr>
<td>Laryngeal mask airway Classic</td>
<td>$80–200 (reusable up to 40 uses)</td>
<td>1.0: &lt;5 kg</td>
<td>First</td>
<td>91 % (first attempt) 99–100% (overall)</td>
<td>15–23</td>
<td>Most widely used for fiberoptic intubation; may be difficult to remove when cuffed tracheal tubes (TT) are utilized</td>
<td>Higher complication rate and lower leak pressures in small infants; potential for gastric insufflation</td>
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<td>1.5: 5–10 kg</td>
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<td>2.0: 10–20 kg</td>
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<td>3.0: 30–60 kg</td>
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<tr>
<td>Laryngeal mask airway Unique</td>
<td>$7–10 Single use</td>
<td>1.0: &lt;5 kg</td>
<td>First</td>
<td>88 % (first attempt) 100% (overall)</td>
<td>15–18</td>
<td>No formal studies evaluating use as a conduit for tracheal intubation; FO views inferior to air-Q</td>
<td>Potential for gastric insufflation</td>
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<tr>
<td>Laryngeal mask airway ProSeal</td>
<td>$100–250 (reusable up to 40 uses)</td>
<td>1.0: &lt;5 kg</td>
<td>Second</td>
<td>94 % (first attempt) 75% (overall)</td>
<td>22–23</td>
<td>Requires two-step technique for larger TTs</td>
<td>Size 1.5 associated with difficult insertion; narrow airway tube requires smaller TT or exchange catheter technique</td>
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<td>1.5: 5–10 kg</td>
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<tr>
<td>Newer SGAs</td>
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<td>air-Q</td>
<td>$7–10 Single use</td>
<td>0.5: &lt;4 kg</td>
<td>First</td>
<td>99% (first attempt) 99–100% (overall)</td>
<td>19–25</td>
<td>High success rates and accommodates cuffed TTs; FO views superior to laryngeal mask airway Unique</td>
<td>Potential for gastric insufflation</td>
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<td>1.0: 4–7 kg</td>
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<td>1.5: 7–17 kg</td>
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<td>2.0: 17–30 kg</td>
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<td>Ambu Aura-i</td>
<td>$5–8 Single use</td>
<td>1.0: &lt;5 kg</td>
<td>First</td>
<td>93 % (first attempt) 98% (overall)</td>
<td>16–22</td>
<td>High success rate; FO views similar to air-Q and i-gel</td>
<td>Size 1 and 1.5 cannot accommodate pilot balloon of cuffed TTs; potential for gastric insufflation</td>
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<td>Laryngeal mask airway Supreme</td>
<td>$10–20 Single use</td>
<td>1.0: &lt;5 kg</td>
<td>Second</td>
<td>97 % (first attempt) 100% (overall)</td>
<td>17–20</td>
<td>No formal studies evaluating use as a conduit for tracheal intubation; requires two-step technique for larger TTs; similar FO view compared with laryngeal mask airway ProSeal</td>
<td>Narrow airway tube requires smaller TT or exchange catheter technique</td>
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<td>i-gel</td>
<td>$10–20 Single use</td>
<td>1.0: 2–5 kg</td>
<td>Second</td>
<td>91 % (first attempt) 93% (overall)</td>
<td>20–27</td>
<td>No formal studies evaluating use as a conduit for tracheal intubation; superior FO view compared with laryngeal mask airway Classic and laryngeal mask airway ProSeal</td>
<td>Spontaneous dislodgement observed in smaller sizes; size 1.0 lacks gastric access</td>
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<td>1.5: 5–12 kg</td>
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<td>3.0: 30–60 kg</td>
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</tbody>
</table>

FO, fiberoptic; TT, tracheal tube.

*Reflects approximate cost in US dollars per single device. Cost may differ depending on distributor and country.
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...dence to suggest the use of a particular device in such emergency situations.

Conclusion

A variety of new SGAs for use in children have emerged since their introduction into clinical practice over 30 years ago. As new devices are introduced into clinical practice, assessing the potential advantages and limitations of each device through thorough clinical evaluations remains important. Table 5 summarizes the SGAs discussed and outlines potential areas of concern.

Despite the many new devices, the laryngeal mask airway Classic, laryngeal mask airway ProSeal, and laryngeal mask airway Unique remain the most ubiquitous devices in pediatric use, and still provide excellent conditions in a wide variety of situations with only a few specific exceptions. For healthy children undergoing routine anesthesia with spontaneous ventilation, the laryngeal mask airway Classic and laryngeal mask airway Unique are suitable devices, except in infants where the laryngeal mask airway ProSeal, air-Q, or i-gel may be preferable for their relative stability during anesthetic maintenance. For PPV, the best options are either the established laryngeal mask airway ProSeal or the newer i-gel for their higher airflow leak pressures, and gastric access. When used as a conduit for tracheal intubation, the air-Q and Ambu Aura-i were designed for this purpose and may better facilitate the tracheal intubation and device removal process when compared with the laryngeal mask airway Classic. For use in emergency situations such as failed intubation and cardiac arrest, a lack of data suggests that pragmatic choices must be made, as both established and newer devices have all been used successfully.

Acknowledgments

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Conflict of interest

No conflicts of interest declared.

References

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